

A Summary of the Study of Extremely Low Emitting Vehicles Operating on the Road in California

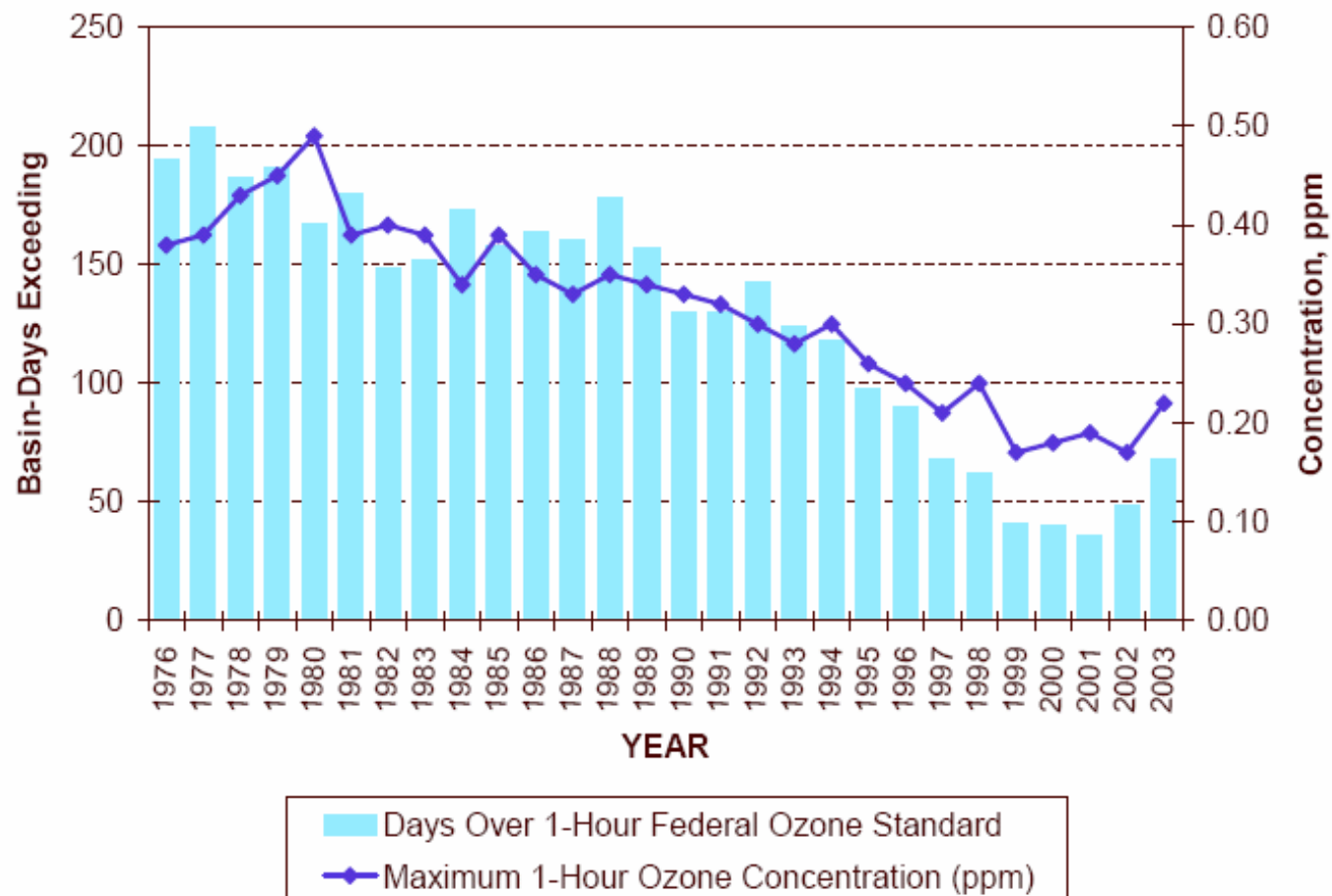
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University of California, Riverside

Presentation to
Committee Workshop on
Air Quality and Opportunities to Expand
Use of Alternative Transportation Fuels

OVERVIEW OF PRESENTATION

- **Review of Air Quality in Los Angeles**
- **Evolution of Emission and Fuel Standards**
- **Study of Extremely Low Emission Vehicles**
 - Gas Phase
 - Particulates
- **Impact of Alternative Fuels**
- **Potential for California Synthetic Fuel Production from Biomass**

South Coast Air Basin Smog Trend



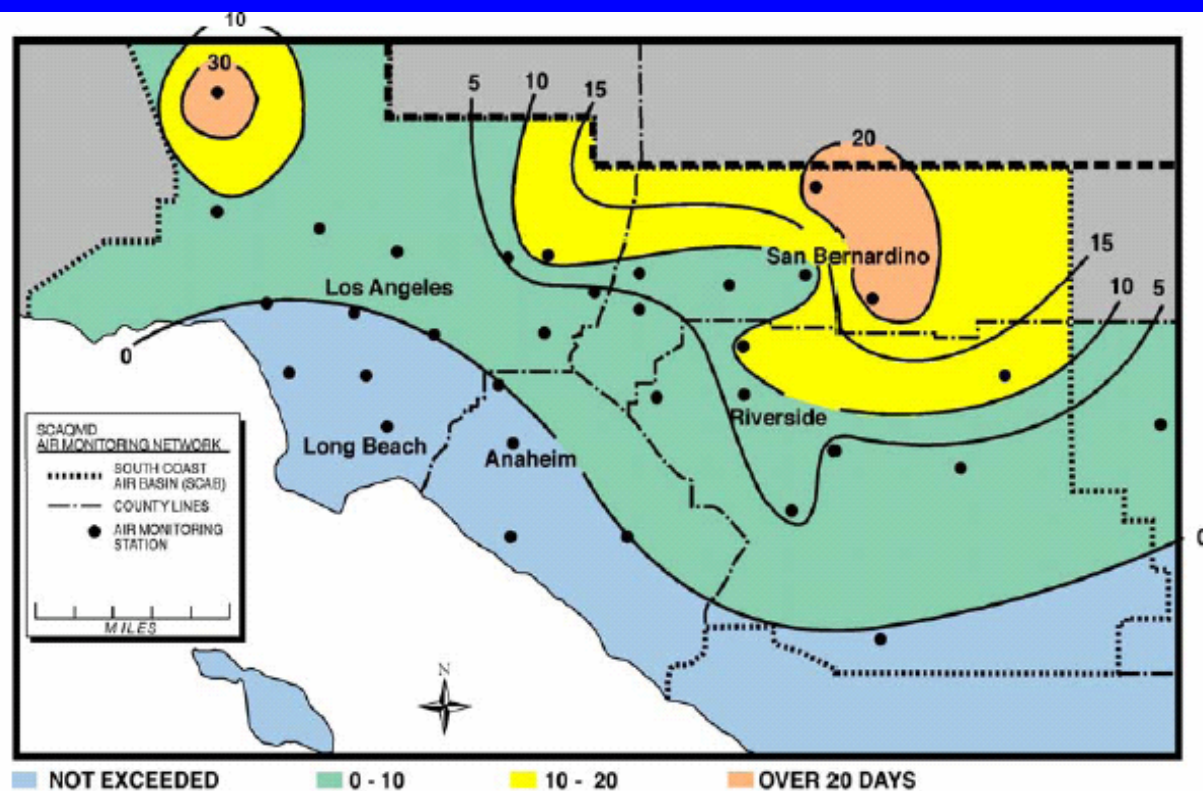


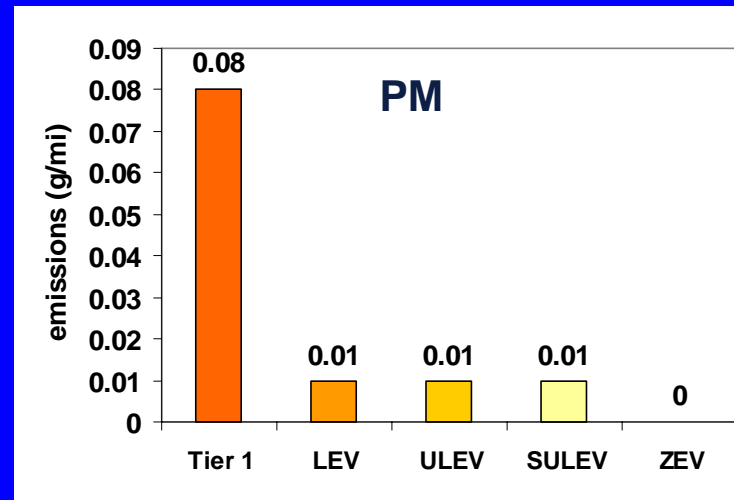
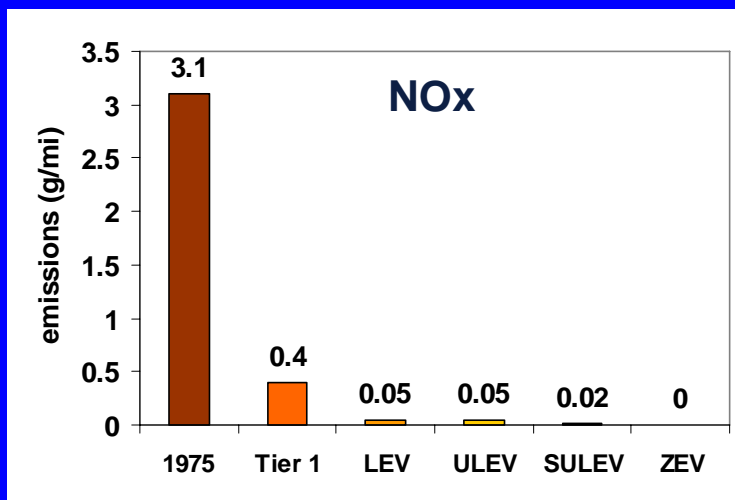
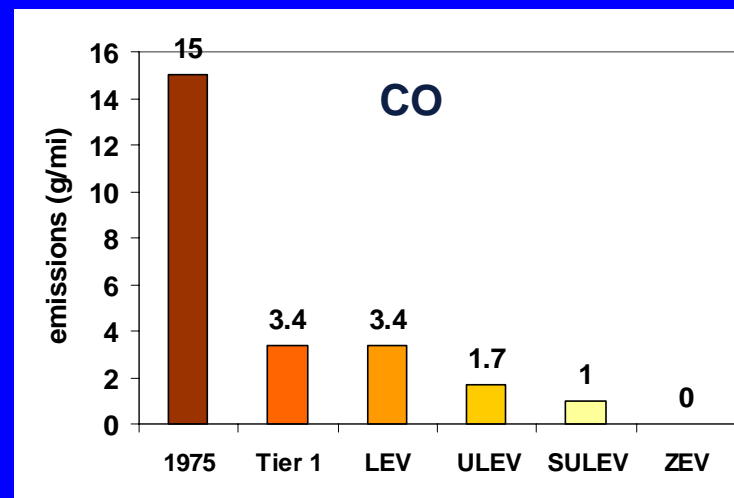
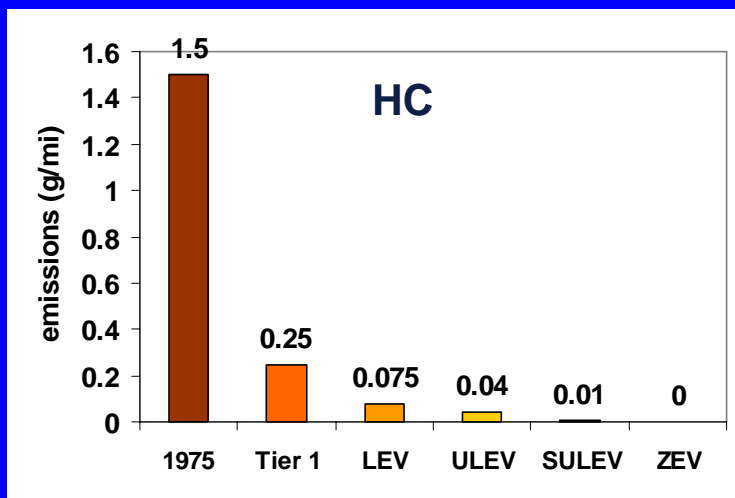
Figure 3
Ozone - 2002
Number of Days Exceeding 1-Hour Federal Standard

Certification Standards vs. Actual Emissions

g/mi	<u>California Tier 0 Standard</u>	<u>Actual Emissions*</u>
HC	0.39 g	3.01 g
NOx	0.4 g	1.46 g
CO	7.0 g	21.4 g
CO ₂	NA	366.8 g

* U.S. EPA, Emission Facts: *Annual Emissions and Fuel Consumption for an "Average" Passenger Car*, April 1998. EPA420-F-98-012.

What Are the Extremely-Low-Emission Vehicles



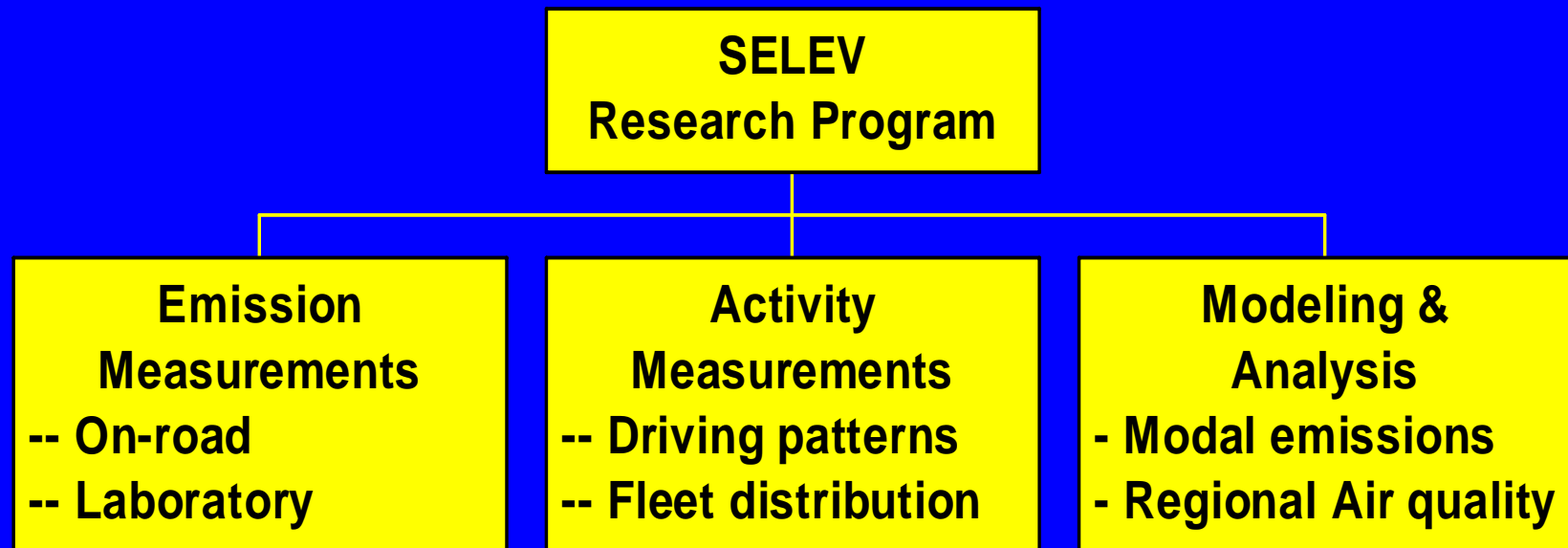
- LEV: Low Emission Vehicle; ULEV: Ultra Low Emission Vehicle; SULEV: Super Ultra Low Emission Vehicle; ZEV: Zero Emission Vehicle; PZEV: Partial Zero Emission Vehicle

Catalyst Efficiency Requirements for Tailpipe Hydrocarbon Control

Emission Level		Catalyst Efficiency	Catalyst Inefficiency
Tier I	Stage II	90%	10%
TLEV		95%	5%
LEV	Stage III	97%	3%
ULEV		98%	2%

(Based on 50K, 2.0 g/mi HC engine-out emissions level)

SELEV Program Organization



Funding Agencies

- **Honda**
- **Chevron**
- **USEPA**
- **California Air Resources Board**
- **MECA**
- **Ford Motor Company**
- **General Motors**

The SELEV Program Objectives

1. **Emissions Measurements:** To develop a method to accurately measure emissions at extremely low levels, both in the laboratory and on the road.
2. **Emissions Modeling:** To adjust the current emissions models to reflect how these ELEV vehicles perform in the real world.
3. **Air Quality Modeling:** To assess the implications of advanced-technology vehicle for atmospheric impacts at the micro, meso, and macro scales.

Laboratory Measurements FTP Tests over Chassis Dynamometer



On-Board Measurements

The FTIR Occupies The Rear Seat Of The Vehicle

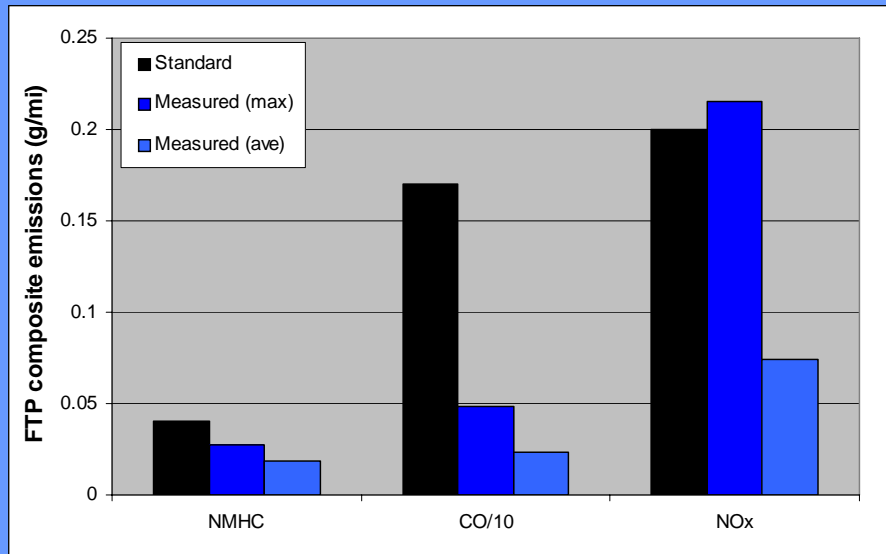


Test Vehicles

Vehicle ID	Certification	Model Year	Make	Model	Odometer
ULEV01	ULEV	2002	Acura	3.2TL	32,344
ULEV02	ULEV	2002	Buick	Regal	21,184
ULEV03	ULEV	2001	Ford	Focus	35,089
ULEV04	ULEV	2002	Ford	Mustang	23,894
ULEV05	ULEV	2002	Honda	Civic	26,632
ULEV06	ULEV	2003	Honda	Civic Hybrid	13,700
ULEV07	ULEV	2001	Mazda	Protégé	27,114
ULEV08	ULEV	2002	Mitsubishi	Galant	22,350
ULEV09	ULEV	2002	Mitsubishi	Lancer	13,300
ULEV10	ULEV	2002	Nissan	Altima	13,747
ULEV11	ULEV	2002	Saturn	L200	14,888
ULEV12	ULEV	2002	Toyota	Camry LE	13,098
ULEV13	ULEV	2003	Toyota	Corolla	21,835
ULEV14	ULEV	2003	Honda	Civic Hybrid	13,700
ULEV15	ULEV	2001	Volkswagen	Jetta GLS	101,049
ULEV16	ULEV	2000	Dodge	Neon	87,766
ULEV17	ULEV	1999	Honda	Accord LX	80,436
PZEV01	PZEV	2003	Honda	Accord EX	7,731
PZEV02	PZEV	2003	Honda	Civic Hybrid	1,502
PZEV03	PZEV	2003	Toyota	Camry LE	2,600
PZEV04	PZEV	2003	Honda	Civic GX	15,191

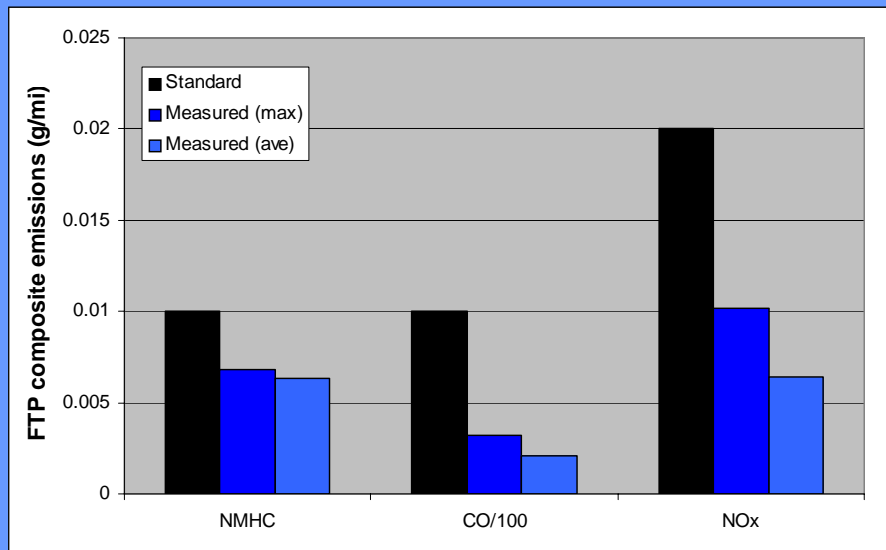
FTP Comparison with the Standards

ULEV



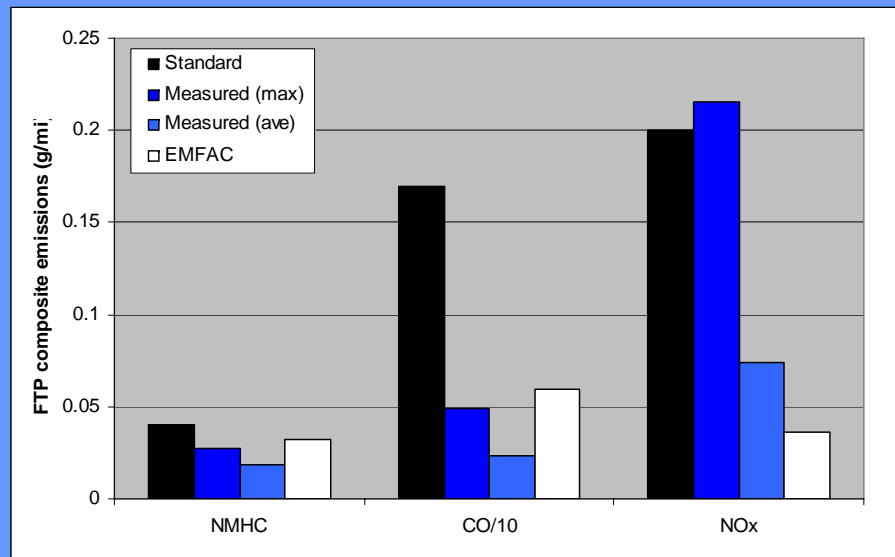
Vehicles
consistently
perform well
below the
standard

PZEV

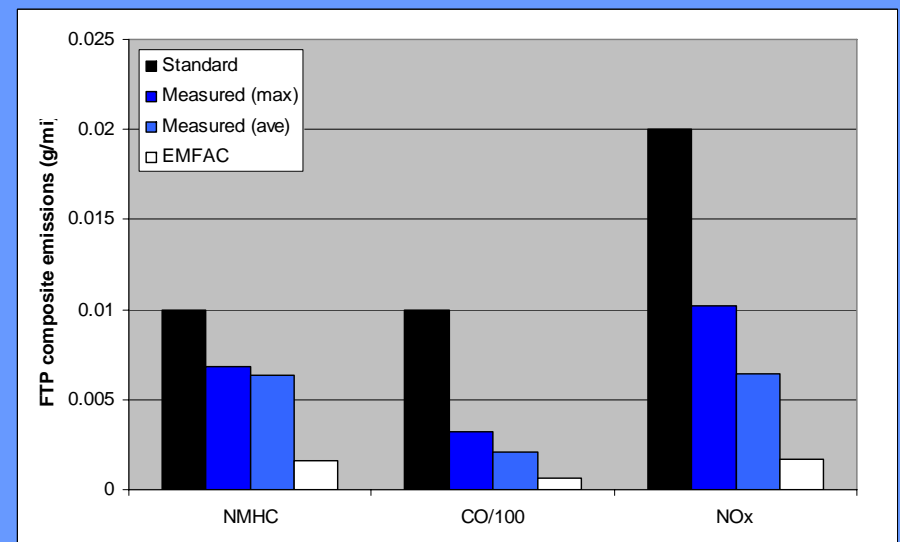


FTP Comparison with the Standard and EMFAC

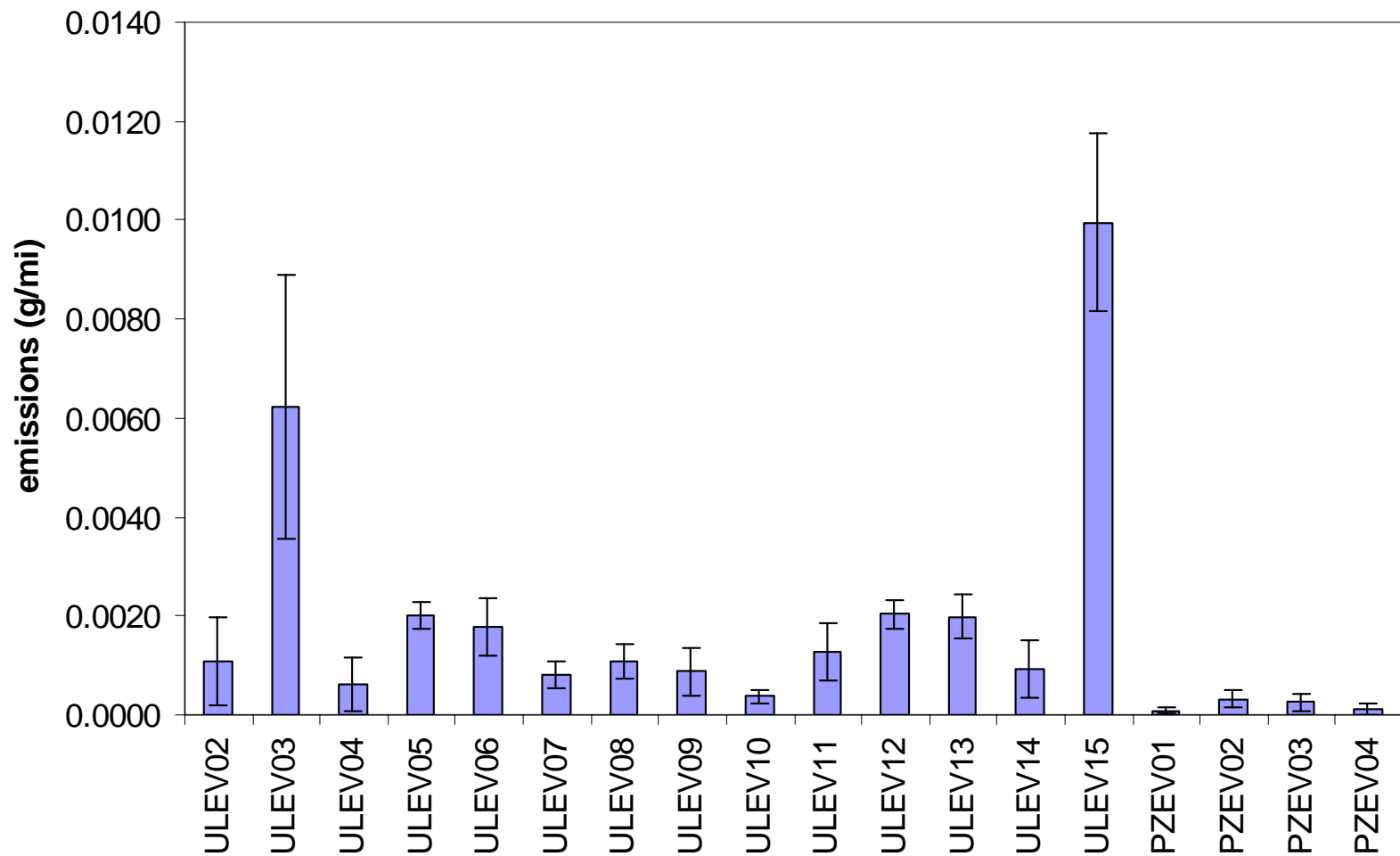
ULEV



PZEV



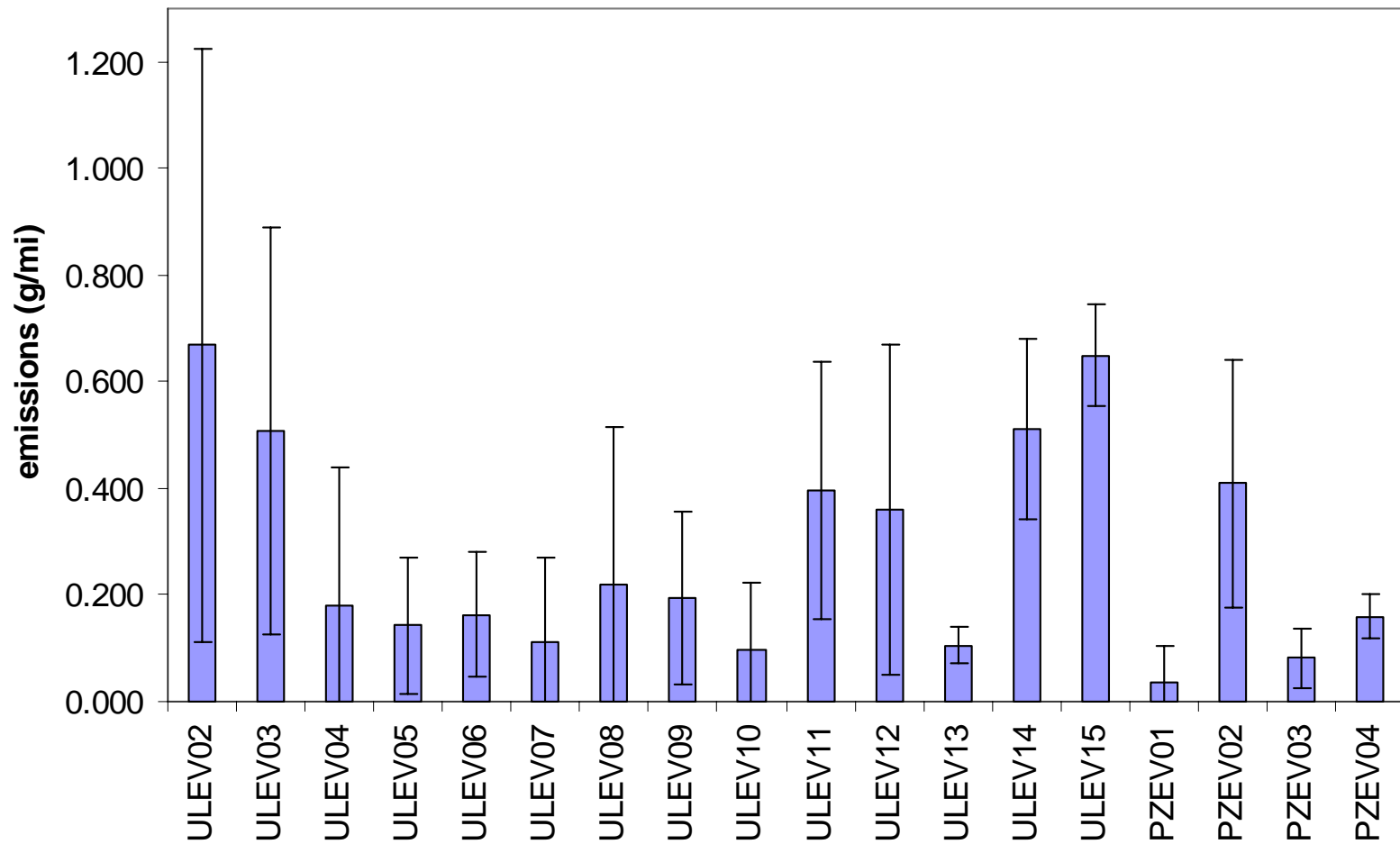
On-Road Emission Rates of NMHC



ULEV Standard: 0.04 g/mi

SULEV Standard: 0.01 g/mi (120,000 miles/11 years)

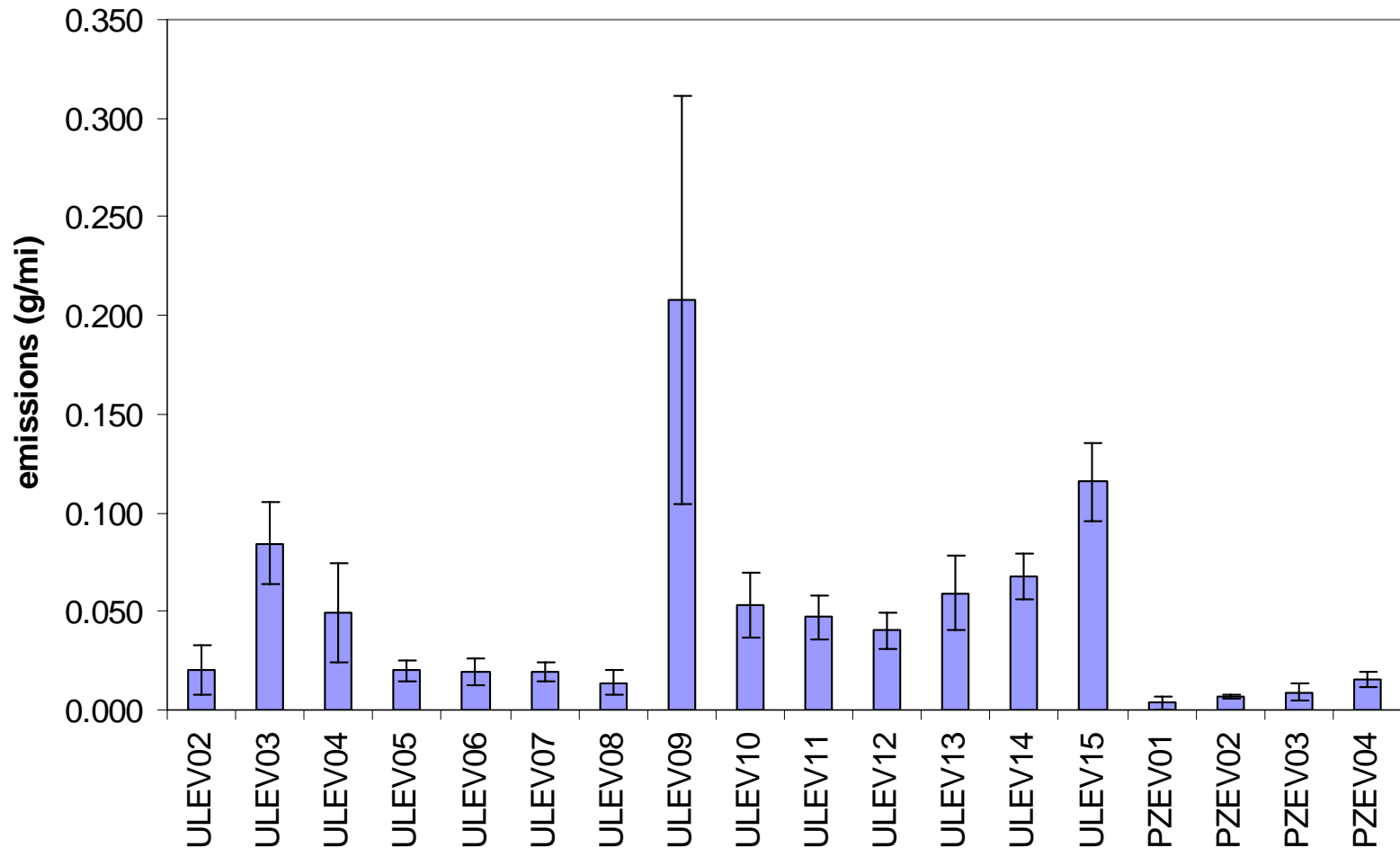
On-Road Emission Rates of CO



ULEV Standard: 1.7 g/mi

SULEV Standard: 1 g/mi (120,000 miles/11 years)

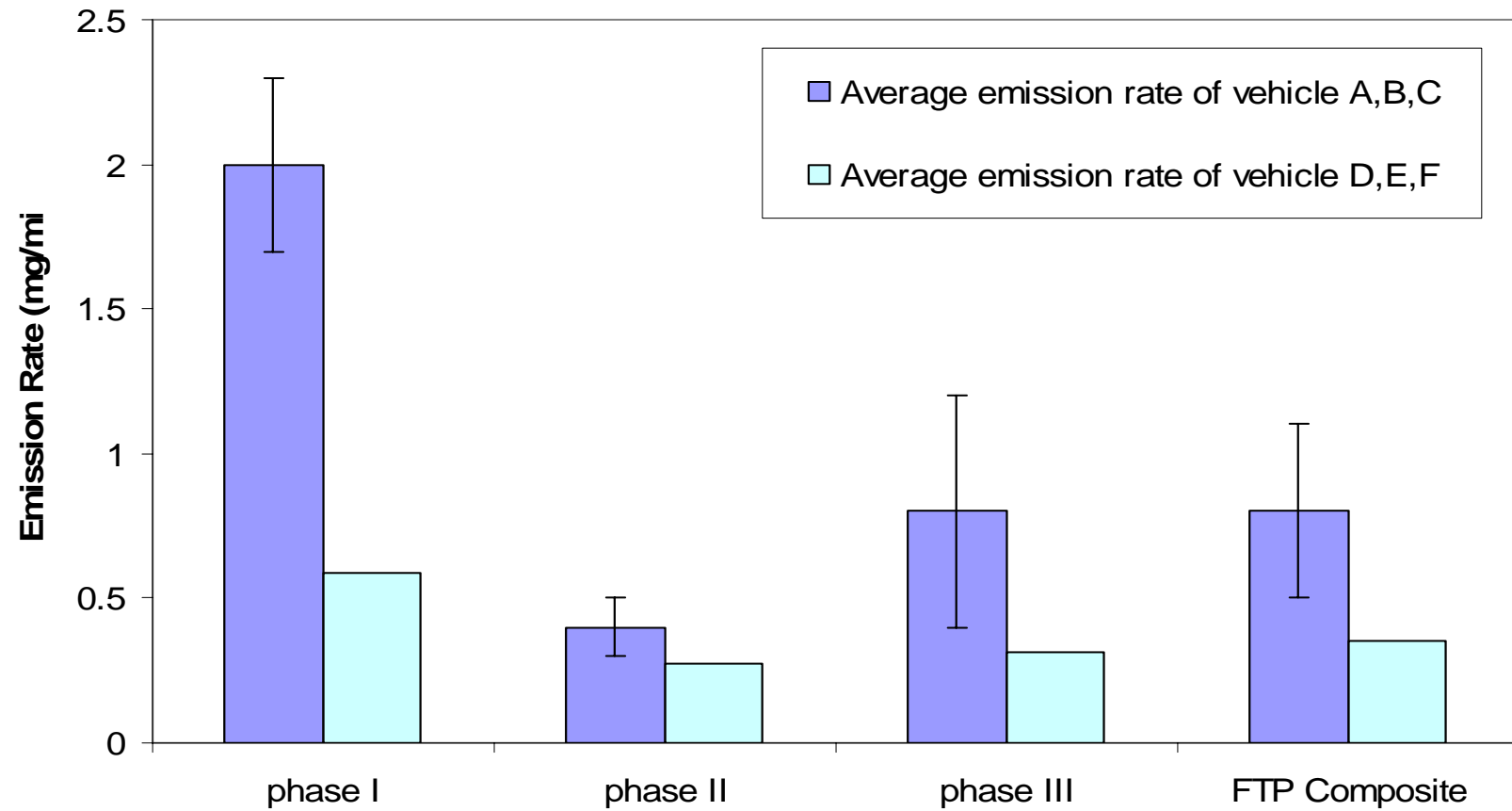
On-Road Emission Rates of NOx



ULEV Standard: LEV program: 0.2 g/mi LEVII program: 0.05 g/mi

SULEV Standard: 0.02 g/mi (120,000 miles/11 years)

Average PM Mass Emission Rates over Multiple Tests



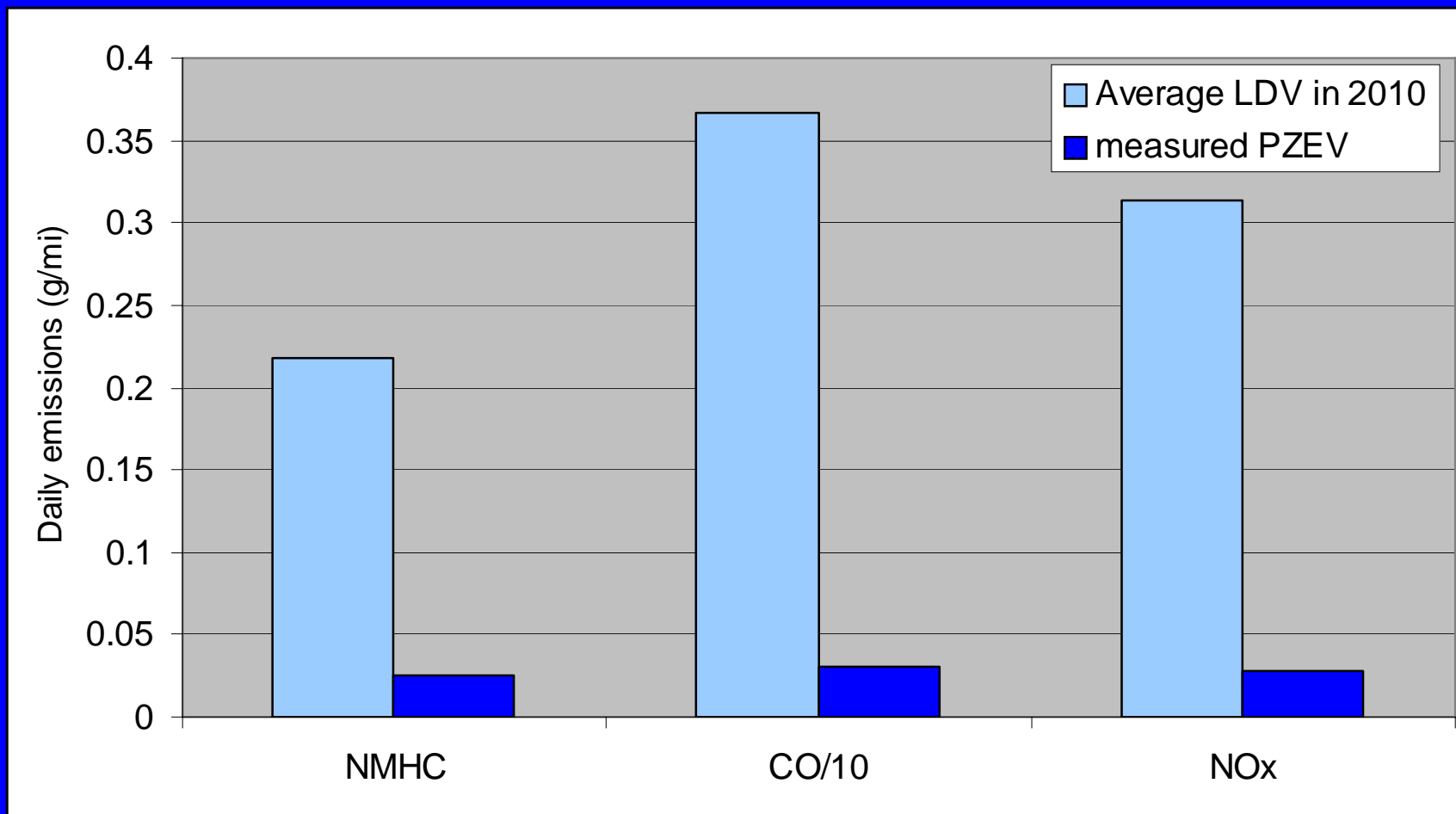
Conclusions: Gas Phase Species

- *The SELEV program has demonstrated that low mileage ELEV vehicles consistently perform on the road with very low emissions*
- *The measurements from the ELEV vehicles are different than the current policy model predictions*
- *Air Quality Modeling indicates that the use of these ELEV vehicles in large numbers could help meet air quality attainment*
- *Impact of Alternative Fuels on Air Quality has diminished to essentially zero.*

Summary and Discussion of PM Emissions

- The PM mass emission rates over FTP tests are around 1 mg/mi or less (<< California LEV II emission standard of 10 mg/mi).
- PM emissions of phase 2 and phase 3 of the FTP tests are dominated by OC; OC emission rates for each phase of the FTP are comparable.
- Phase 1 of the FTP test contributes to most of the particulate mass and number emissions. Mass and number are approximately same relative ratio.
- Further research is needed to fully address potential known artifacts and testing variability. However, we feel these data provide an important first step in this process.

PZEV emission rates compared with the Fleet

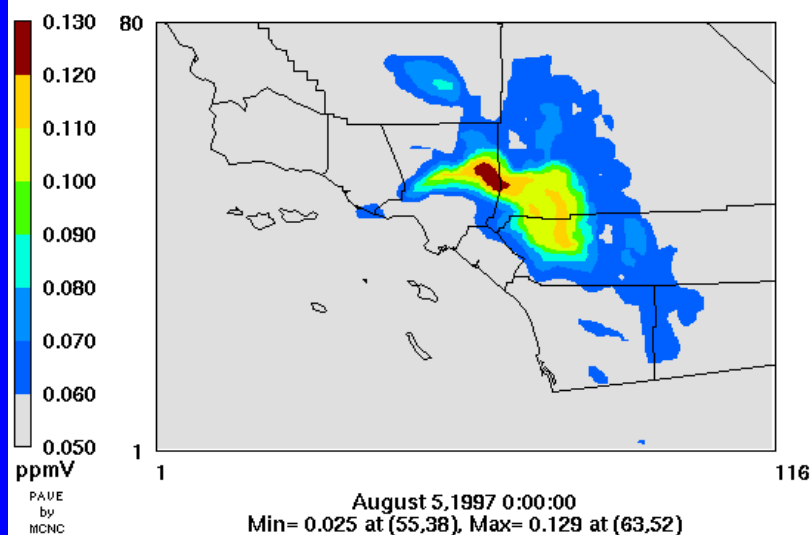


PZEV emission rate ~ 1/10 of the average LDV in 2010

Air Quality Modeling Results

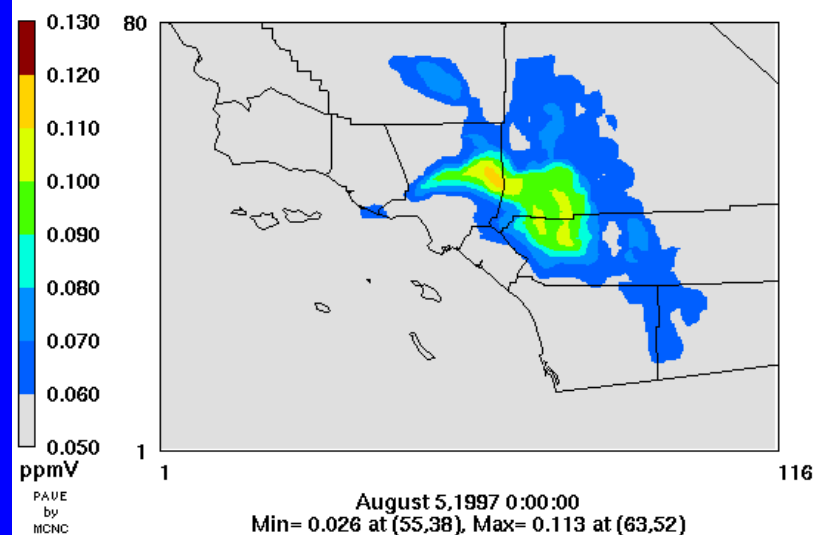
CMEM Base Case 2010 Surface Ozone

model peak O3 at 5 PM PDT August 5, 2010, No Black Box



CMEM Scenario 3 Surface Ozone

model peak O3 at 5 PM PDT August 5, 2010



Conclusions

- *To date, the most important technical finding is that emissions from gasoline powered light duty vehicles that meet the most stringent emission standards for California are operating well below their certification levels. This is true for both laboratory measurements and in real world, on-road conditions. It is a combination of advanced catalyst technology, advanced fuel metering technology, and enabled by clean fuels.*

Concluding Remarks

- Extremely low emitting vehicles entering the California fleet can operate on alcohol fuels and/or gasoline without modification.
- Environmental impact back is independent of fuel.
- Main driver for alternative fuels should be energy independence and global climate change
- California needs to become more aggressive in development of clean alternative fuels.